Technician Licensing Class Introduction

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Special thanks to K3DIO

The Plano Amateur Radio Klub (TX)

Some of this material comes from them

Electronic Fundamentals

- Terms and types
- Measuring, Power and Math
- Electronic components
- Electrical Safety

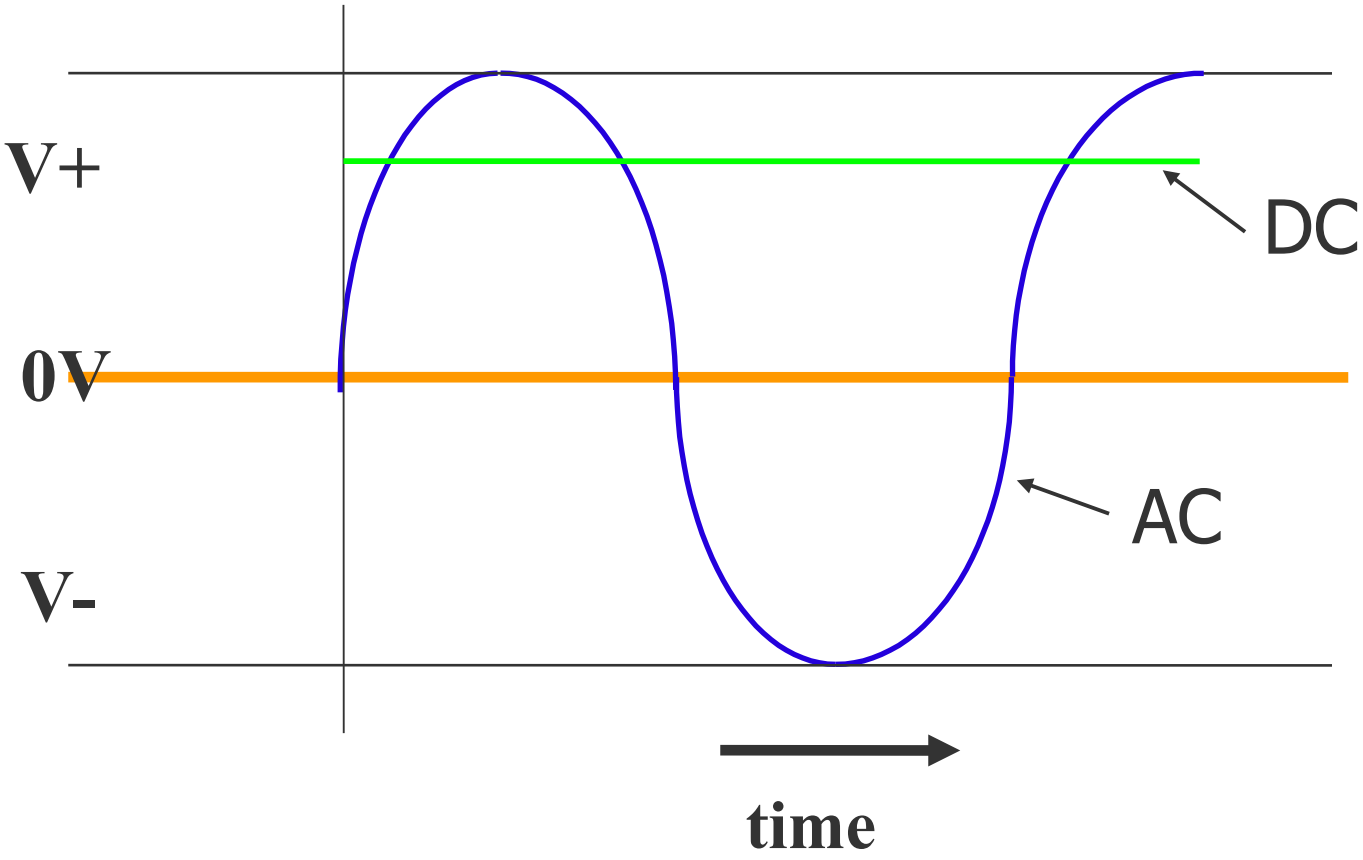
Electricity Terms

- Voltage (V)
  - How much "energy potential" there is
  - Similar to the height of a waterfall
  - Measured in "**Volts**"
  - **electromotive force (EMF) that causes electron flow**
- Current (I)
  - How much is **flow**ing
  - Similar to the size of a waterfall
  - Measured in "**Amps**"

Types of Electricity

- Direct Current (DC)
  - Electrons flow from negative to positive
  - E.G. Batteries
  - Subject to voltage loss over distance
  - All electronics use DC internally
- Alternating Current (AC)
  - Electrons **reverse directions** (cycle)
  - e.g. U.S. Home Wall Sockets: 110V
  - Less prone to voltage loss over distance
  - Must be converted to DC for most usage

AC vs DC



Amplitude: the “peak” of the high and low cycles

Measuring Electricity

- DC
  - Is measured as a linear value
  - It doesn't change, so it's easy
- AC
  - The voltage/current constantly rise and fall
  - Normally measured by average amplitude
  - How fast it alternates is measured in time
    - “Hertz”: How many cycles per second

Power

- Power measures the energy
  - **Rate at which electrical energy is used**
  - Multiplication of:
    - How much current is flowing
    - How many volts
  - P = I * V
    - Power = Current * Voltage
  - Measured in "**Watts**"

Power = Voltage times Current

Low Voltage, High Current
(small height, lots of water)

High Voltage, Low Current
(big height, little water)

Power of both: Low!

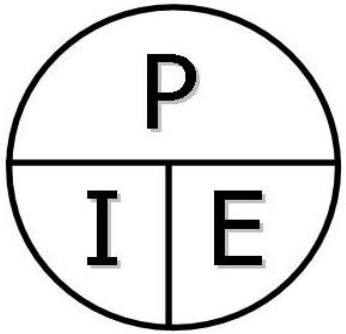
Power = Voltage times Current

Lots of Voltage!
Lots of Current!

High Power!

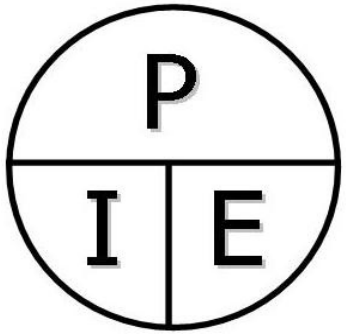
Easy to Remember Helpers

- P = I * E
  - P = I * I * R
  - P = E * E / R
  - Drawn in everyone-loves-pie order!



Test Time

- How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes?
- How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes?
- How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts?



Measuring Power: decibels

- Power difference is measured in "dB"
  - Logarithmic scale
  - **3dB = ~2x power**
  - **6dB = ~4x power**
  - **10dB = 10x power**
  - 20dB = 100x power
  - 30dB = 1000x power
- Only makes sense with a reference!
- What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts?

Circuit Schematics

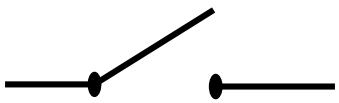
- A circuit schematic **accurately** shows
  - how components are **interconnected**
- Symbols in a schematic
  - **Represent electrical components**
  - Sort of standardized, with differences
    - *U.S. symbols are sometimes slightly different*
  - **You need to know the symbols!**

Conductors and Insulators

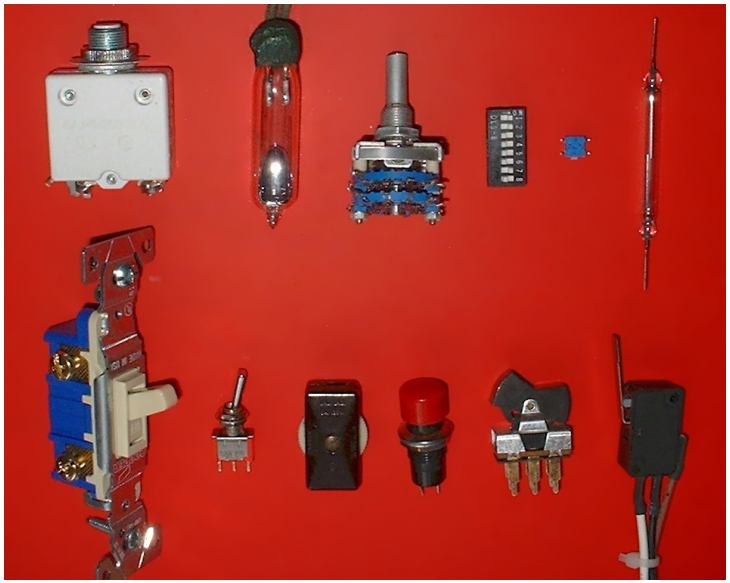
- Conductors:
  - Very Low resistance (near 0)
  - Most metals (copper, gold!, aluminum)
- Insulators:
  - Very high resistance (near infinity)
  - Glass, ceramics, plastic, rubber

Switch

- **Connects and disconnects circuits**
- **Types**
  - Poles: how many circuit connections
  - Throws: How many physical positions
- **Relay**
  - Switch controlled by an **electromagnet**
- **Symbol:**

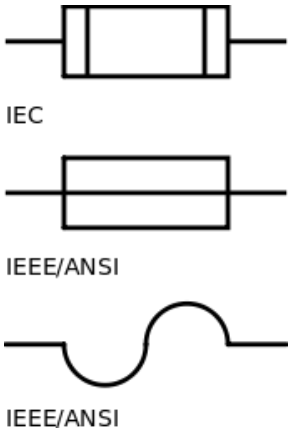


Single poll, Single throw



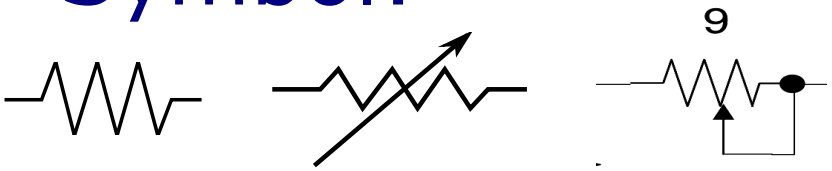
Fuse

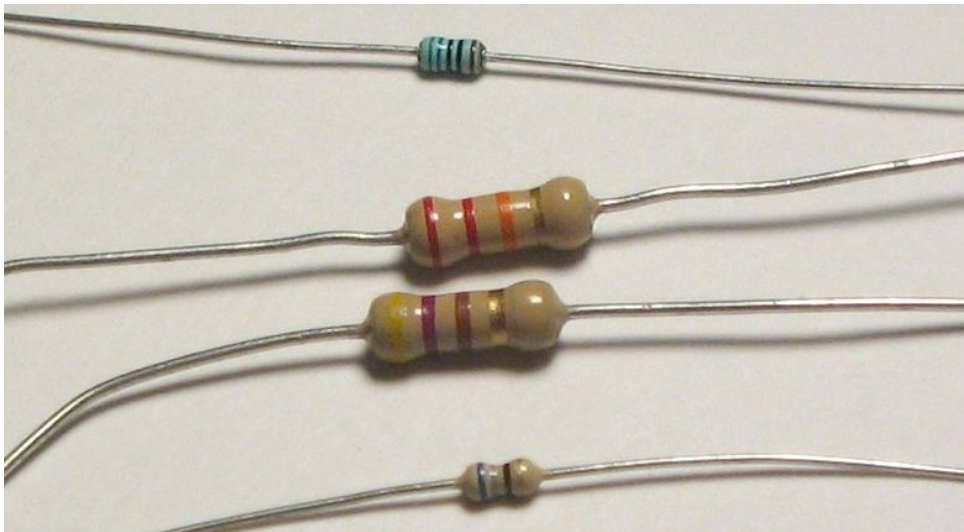
- **Protects a circuit** from current overloads
  - Don't install a bigger fuse in place of a smaller one, excess current **can cause fire**
  - **All 110 AC should have a fuse**
- Either breaks, or is resetable
- Symbol:



Resistance – Resistor

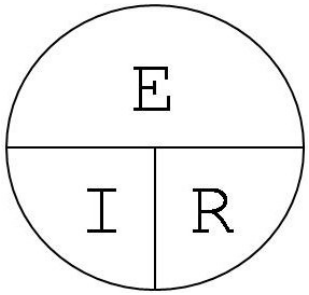
- Measures how "**opposed**" electricity is from flowing through an object
  - **Volume controls** are adjustable resistors!
  - **Potentiometer**: adjustable resistor
- Measured in "Ohms"
- Similar to small vs large water pipes
- V = I * R
  - **"Ohms Law"**
- Symbol:





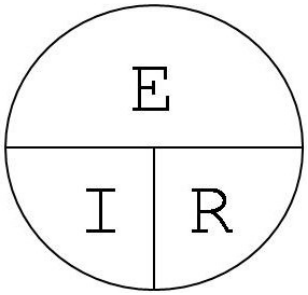
Easy to Remember Helpers

- E = I * R
  - (Some use 'E', some use 'V')
  - Drawn in alphabetical order!



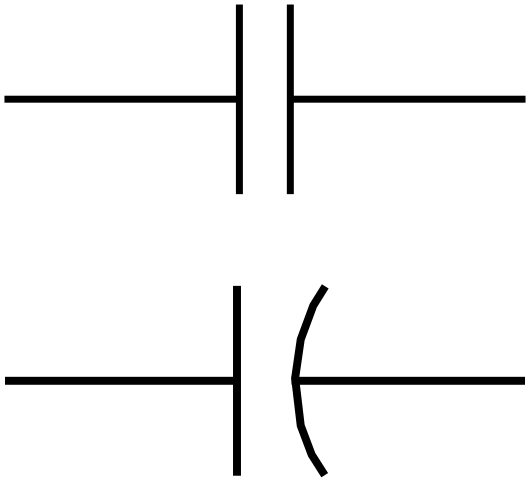
Test Time

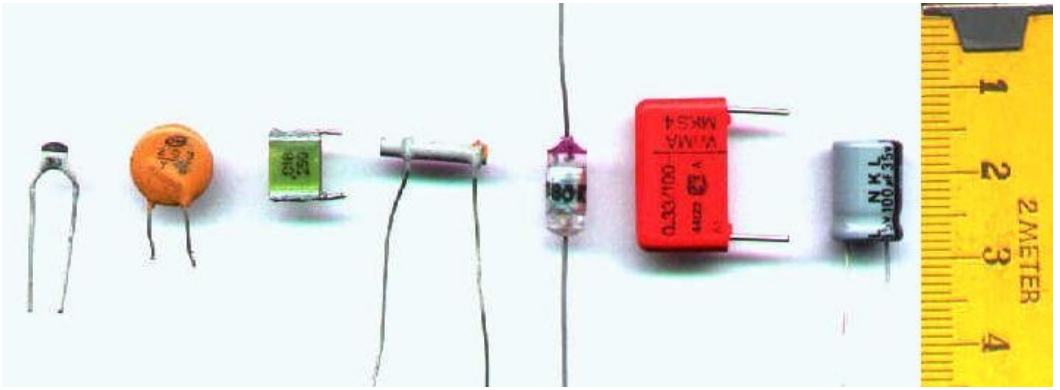
- What formula is used to calculate resistance in a circuit?
- What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts?
- What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?
- What is the resistance of a circuit that draws 4 amperes from a 12-volt source?
- **9 questions like this!!!**
  - **You will get one!**



Capacitance – Capacitor

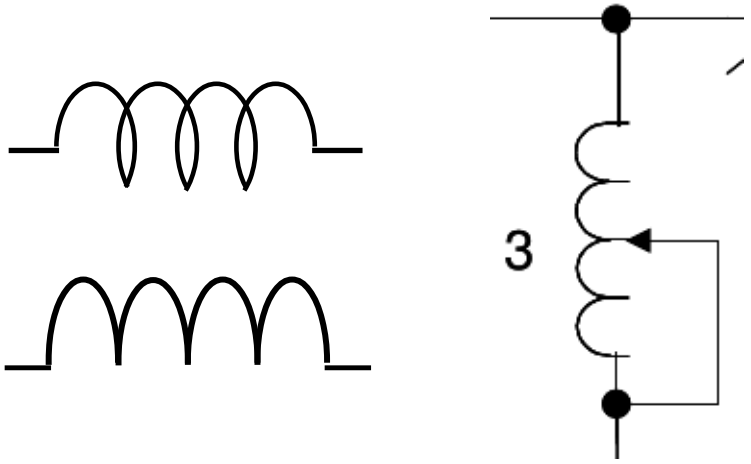
- **Stores energy in an electric field**
- Measured in "**Farad**"s
- **2 electric surfaces**
  - With a good **insulator between them**
- **"Schematic Symbols"**:





Inductance – Inductor

- **Stores energy in a magnetic field**
- Measured in **"Henry"s**
- Built with a **coil of wire**
- **Symbols:**

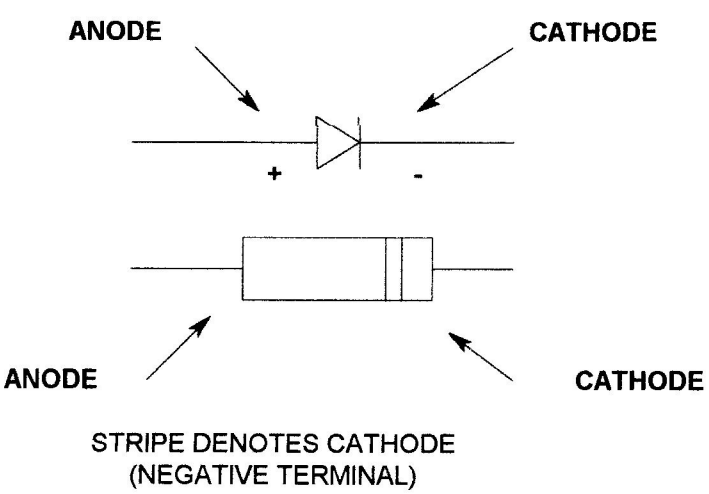


Inductors and Capacitors

- Work wonders together
  - **Tune a circuit to a frequency**
-

Diode

- A "one way valve"
  - Current can **flow in only one direction**
- Two electrodes (connectors)
  - Anode and cathode
  - **Cathode lead: identified by a stripe**
- "Light Emitting Diode"
  - **LED** 
  - A **"visual indicator"**
- Symbol:



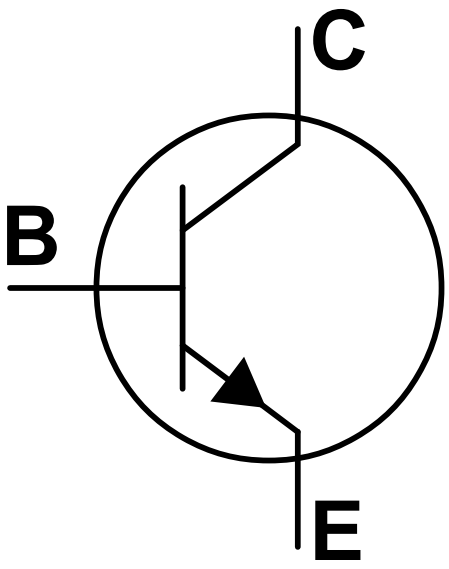
Lamp

- A light. Big or small.

Transistor

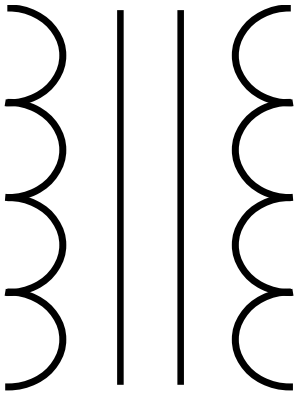
- **Controls current flow** through it
  - Is **controlled by voltage** on a third pin
- **Can amplify signals: "Gain"**
- **Can be used as** an electronic **switch**
- Types:
  - **Field Effect Transistor** **FET**
    - **Has a gate electrode**
  - Bipolar junction transistor
    - **Made with three layers of a semiconductor**
    - **Has an emitter electrode**

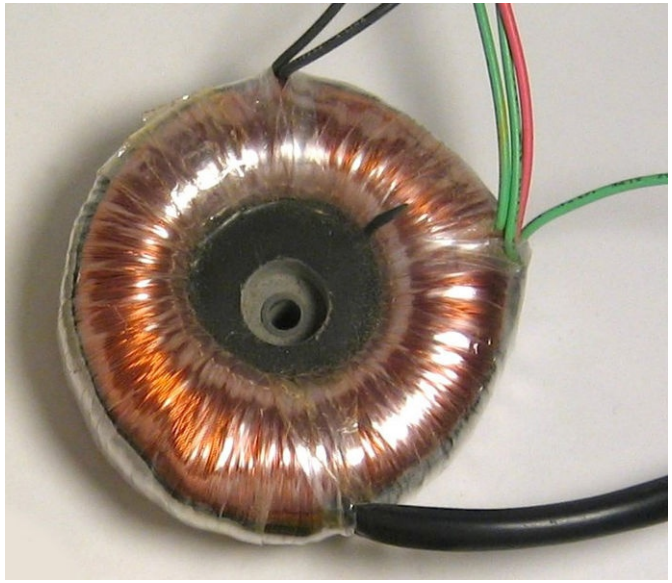
Transistor



Transformer

- Transfers energy between two circuits
  - Uses electromagnetic conduction
  - Can be used to **change voltages**
  - Wire wrapped around a common core
- Symbol:





Antenna

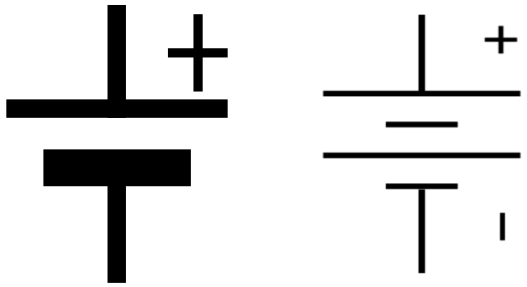
- We'll talk much much more about this
- Symbol:

Sources of Power

- Power supplies
  - Deliver AC power at 110V or 220V
- Batteries
  - AA, AAA batteries: ~1.5V
  - Car batteries: ~12V
- Generators
- Solar cells
- Wind
- ...

Batteries

- Symbol



Batteries

Type	**Rechargable?**	**Nominal Voltage**
Alkaline	N	1.5V
Carbon-Zinc	**N**	1.2V
Nickel-cadmium (NiCad)	Y	**1.2V**
Lithium Ion	Y	3.6V

Equipment

A **Power Supply** is the device used to convert the alternating current from a wall outlet into low-voltage direct current.

An **RF Power Amplifier** is a device used to increase the output of a 10 watt radio to 100 watts.

Equipment: Batteries

A **Lithium-ion battery** offers the longest life when used with a hand-held radio, when comparing battery types of the same physical size.

Recharge your **12-volt battery with your car** if the power is out

Conventional 12 volt batteries **need venting: explosive gasses can build up**

Battery Care

- In order to keep rechargeable batteries in good condition and ready for emergencies:
  - They must be inspected for physical damage and replaced if necessary
  - They should be stored in a cool and dry location
  - They must be given a maintenance recharge at least every 6 months
- The best way to get the most amount of energy from a battery is to draw current from the battery at the slowest rate needed.

Measuring Electricity

- Displaying signal strength
  - Numerically: A "**meter**"
- Measuring voltage (EM force)
  - A **voltmeter**
- Measuring current
  - A **ammeter**
- Measuring Resistance
  - An **ohmmeter** or potentiometer
- A multi-meter does all 3

Measuring Electricity: multi-meters

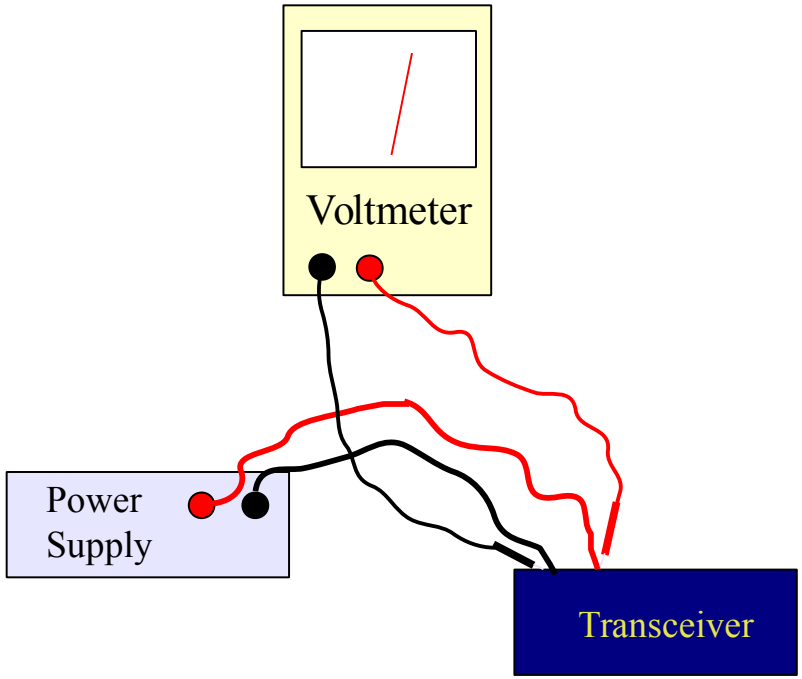
Be sure it is set properly to read what is being measured.

If it is set to the **resistance setting and voltage is measured the meter could be damaged**!

Ensure the **circuit is operating at the correct frequency** when measuring resistance!

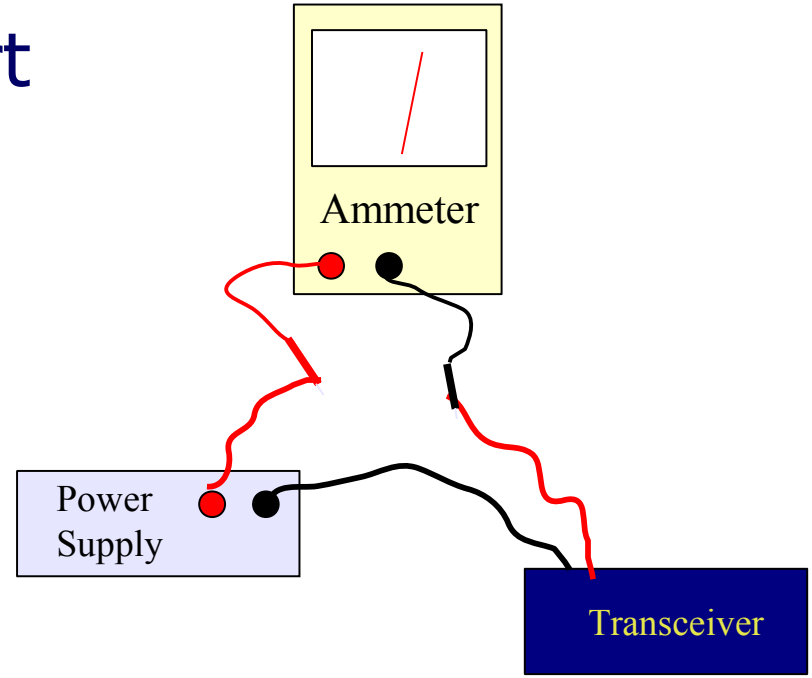
Measuring Voltage

- Measured between two points
  - Can be done without changing the circuit
  - **Connect in parallel**



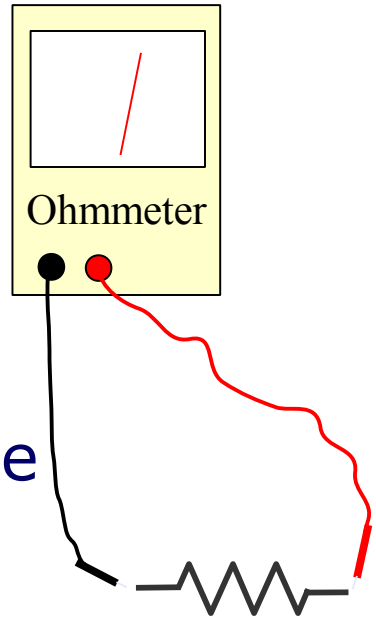
Measuring Current

- To measure current you MUST interrupt the circuit to put the meter between two points
  - It becomes part of the circuit
  - **Connect in series**



Measuring Resistance

- Measures across the resistor
  - Puts voltage across it
  - Measures the current through it
  - If the resistance changes,
    - **The circuit containing a capacitor**
    - i.e. the voltage is getting stored in the capacitor slowly until it's full



Circuits – Connecting it all together

- Previous slides were about “parts”
- Circuits connect components together
  - Integrated circuits **combine several components together** into one package
  - Motherboards, etc
- Larger parts are soldered together or to a circuit board
  - A **rosin-core** solder is best to use
  - “**cold**” solder joints are **grainy or dull**

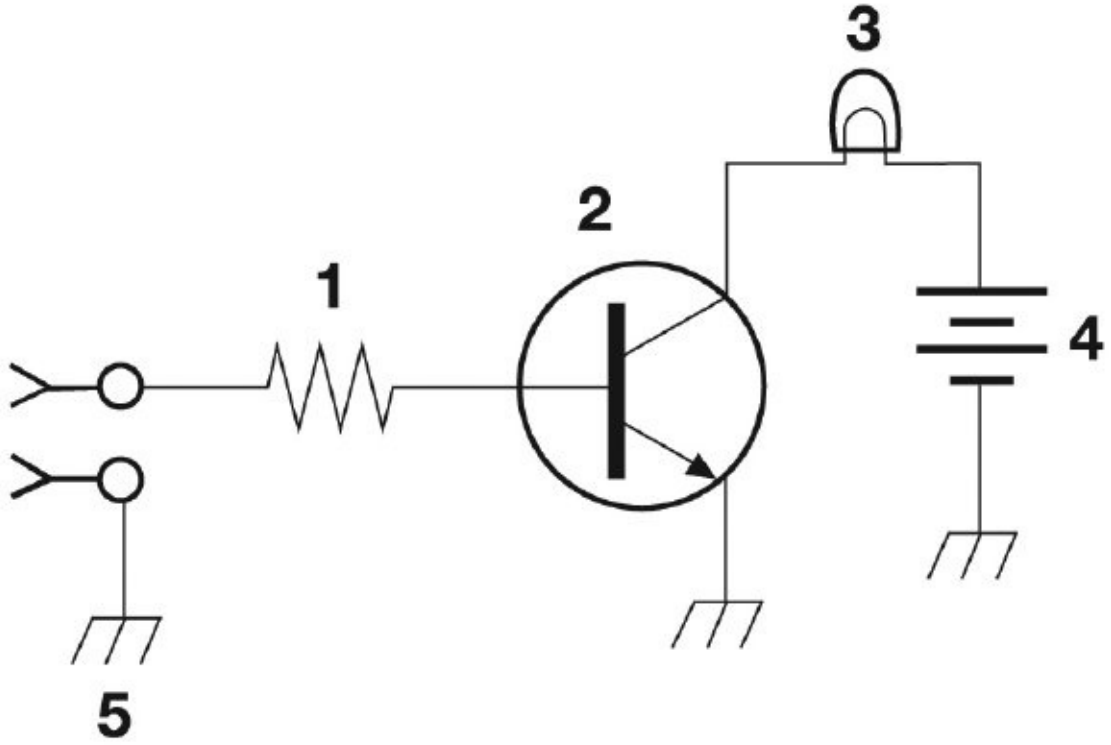


Figure T-1

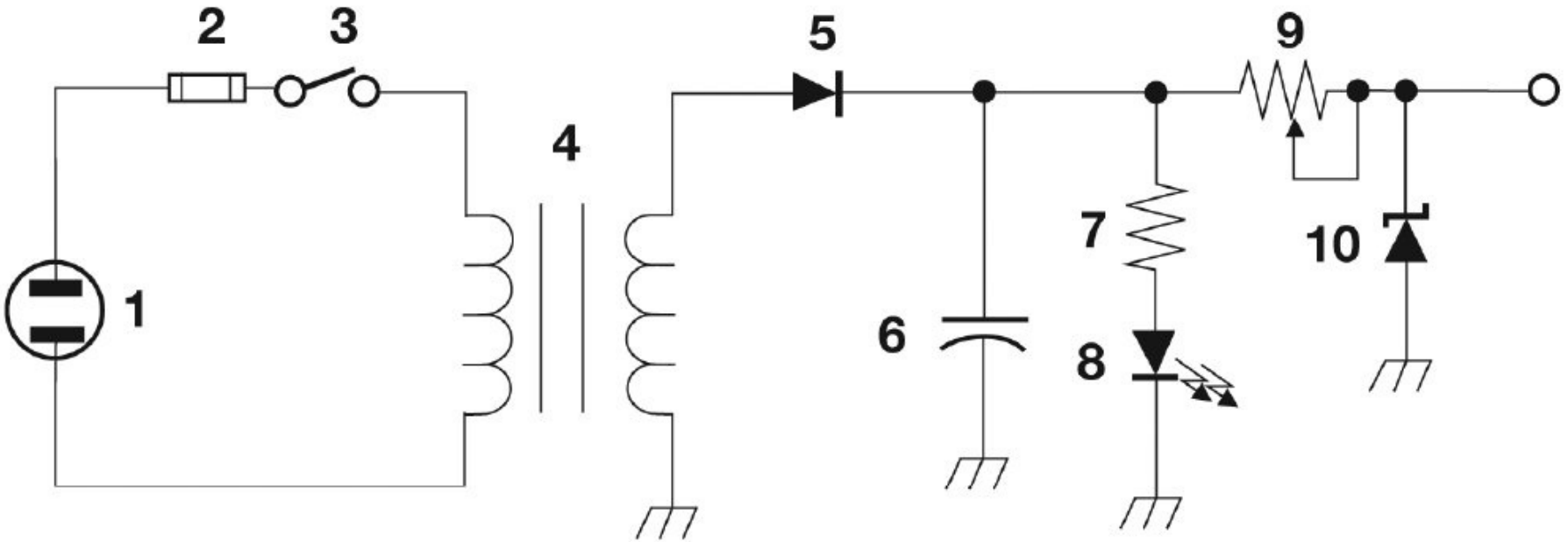


Figure T-2

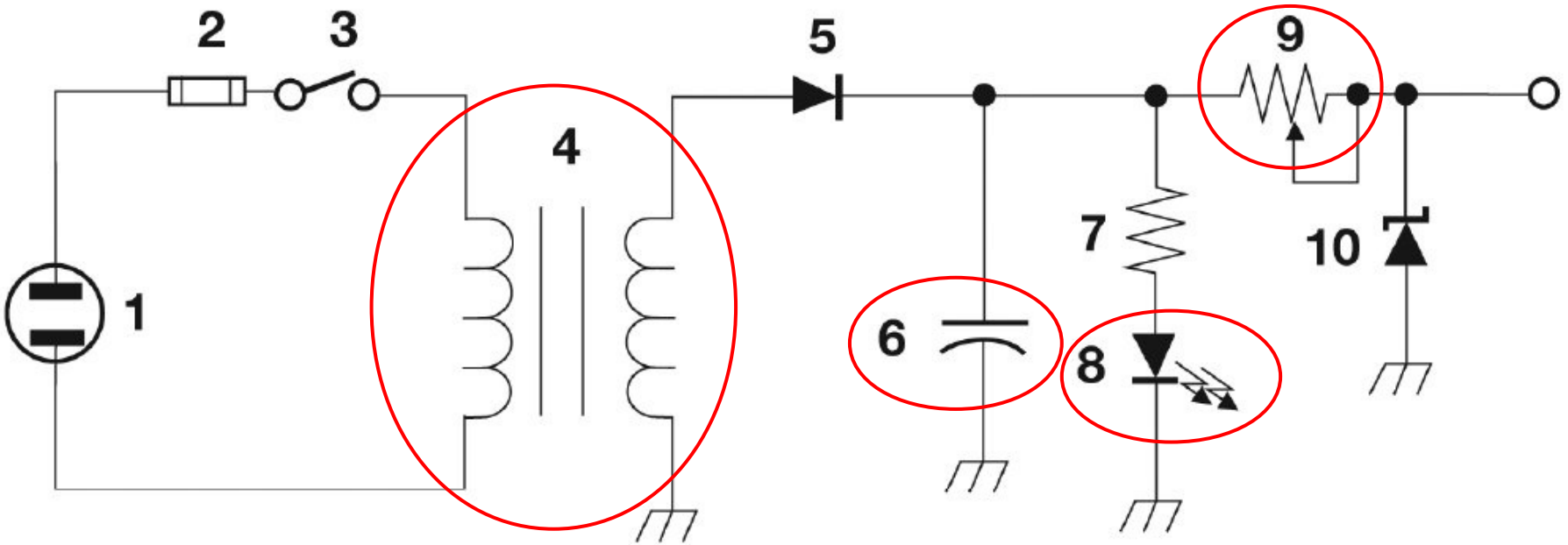


Figure T-2

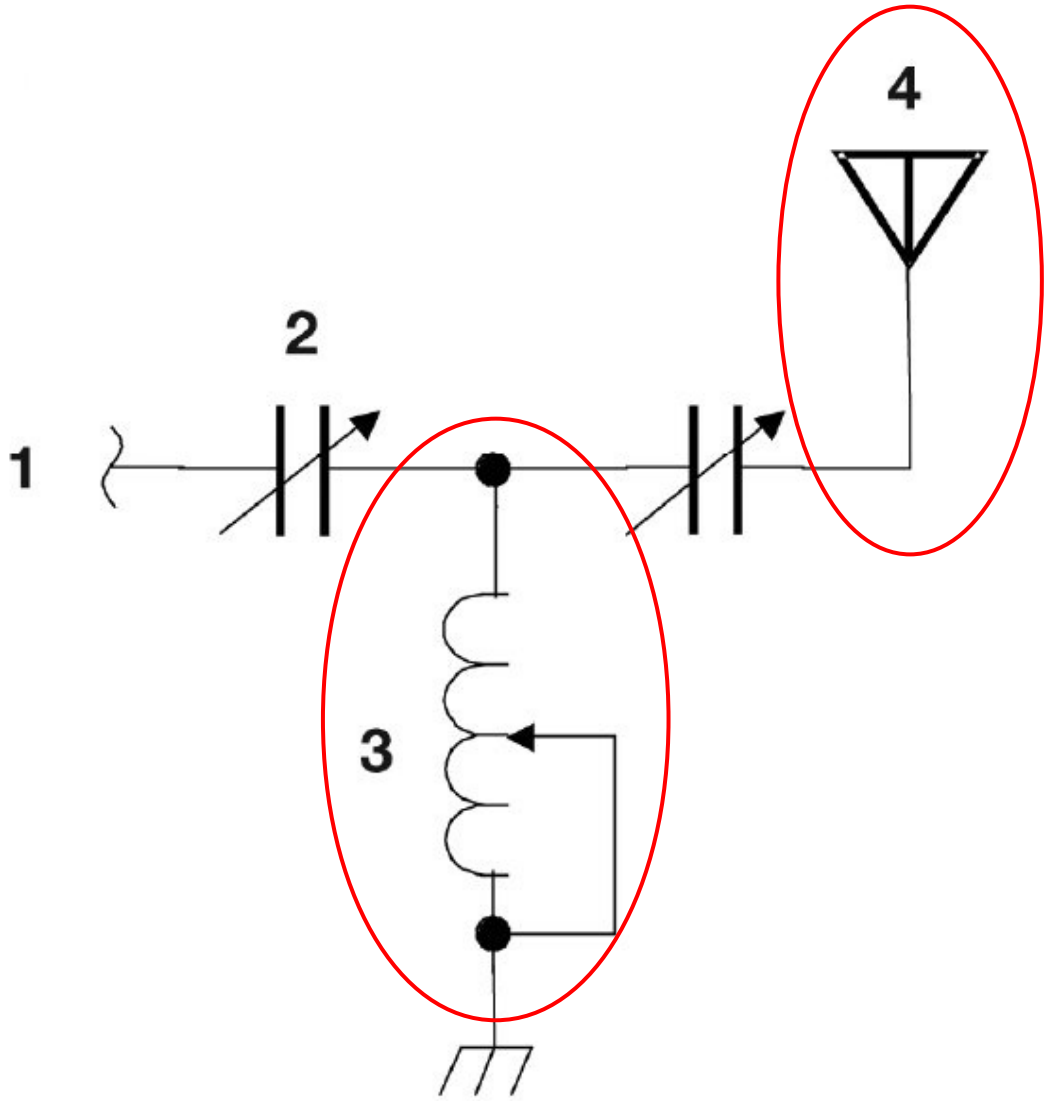


Figure T-3

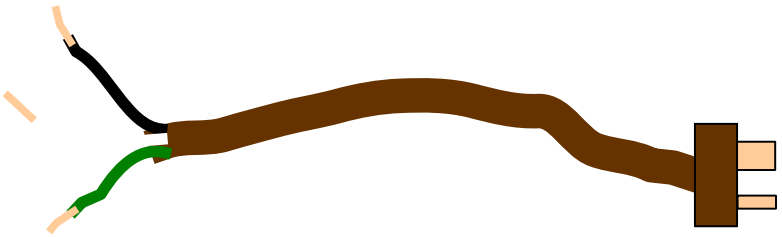
Electricity Safety

- Power supplies have charge when turned off
  - Capacitors hold charge for a while
- **To prevent electric shock**
  - Use 3-wire cords for all AC equipment
  - Connect station equipment to a common ground
  - Use a ground-fault interrupter

Electricity Safety

- Current kills more than voltage
  - (but they're related, obviously)
  - Heats tissue
  - Disrupts electrical functions in the cells
  - Involuntary muscle contractions
- Lowest safe current
  - Only **100 milliamps!!**
- Lowest shock voltage
  - **30 volts**
- **Green** wire of a 3-wire cord is **ground**

Electrical Safety



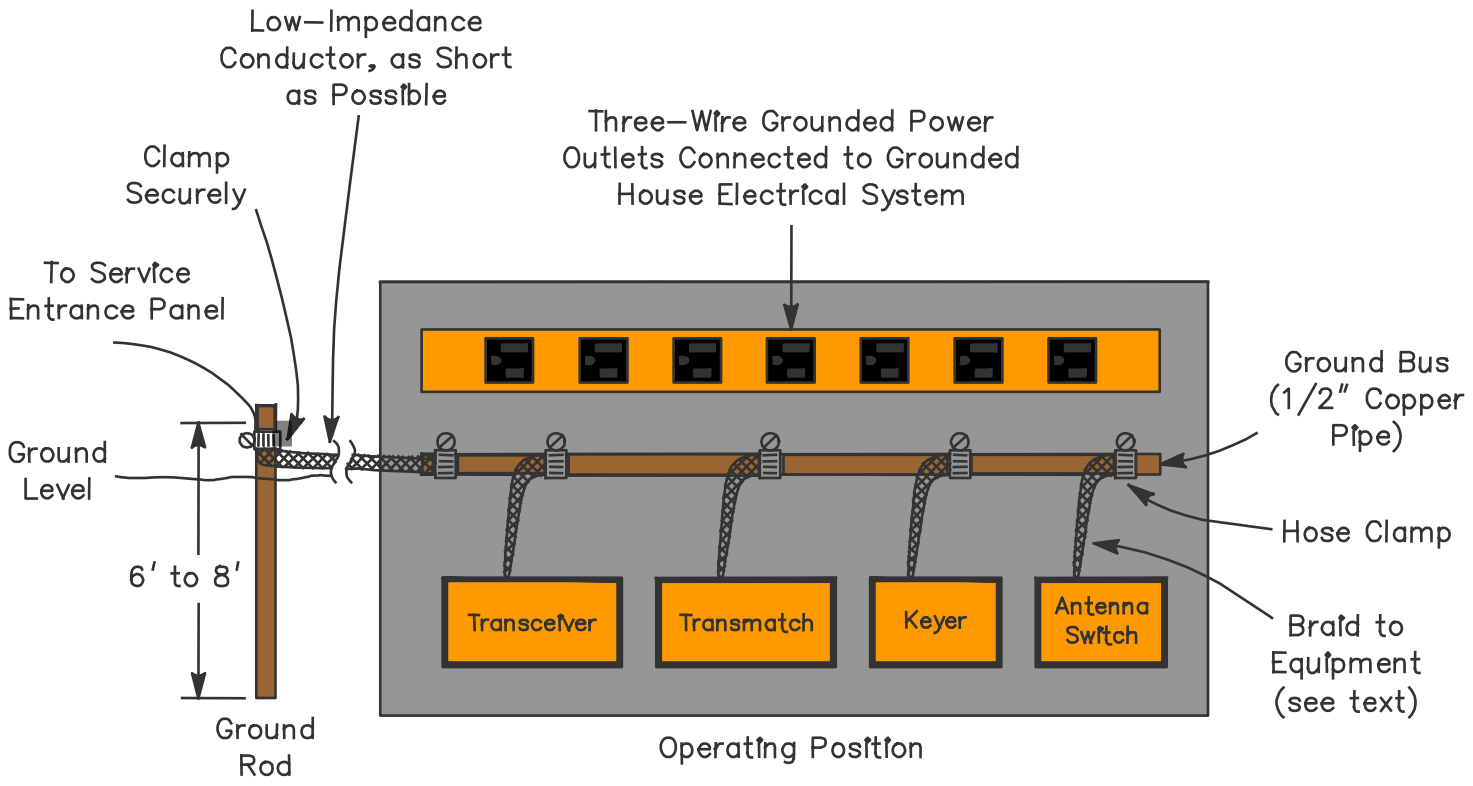
- In a three wire AC electrical line:
  - Black is HOT
  - White is NEUTRAL
  - Green is Chassis Ground

Breaker box Service Disconnect on left.

Lightening Safety

- To protect equipment against lightning
  - **Ground everything to a common plate**
- To protect you:
  - **Disconnect the antenna cables from your station and move them away from your radio equipment**
  - Unplug all power cords from AC outlets
  - Stop using your radio equipment and move to another room until the storm passes
- If you hear it, it can harm your radio!

Grounding



External

Inside

Grounding

- Lightening grounding vs RF grounding
  - Lightening grounding:
    - for protection
  - RF grounding:
    - For better transmissions / reception
    - For shock safety
    - **Flat Strap** ground cable is best

Questions?